INDIAN INSTITUTE OF TECHNOLOGY PATNA

CS225 : Switching Theory.

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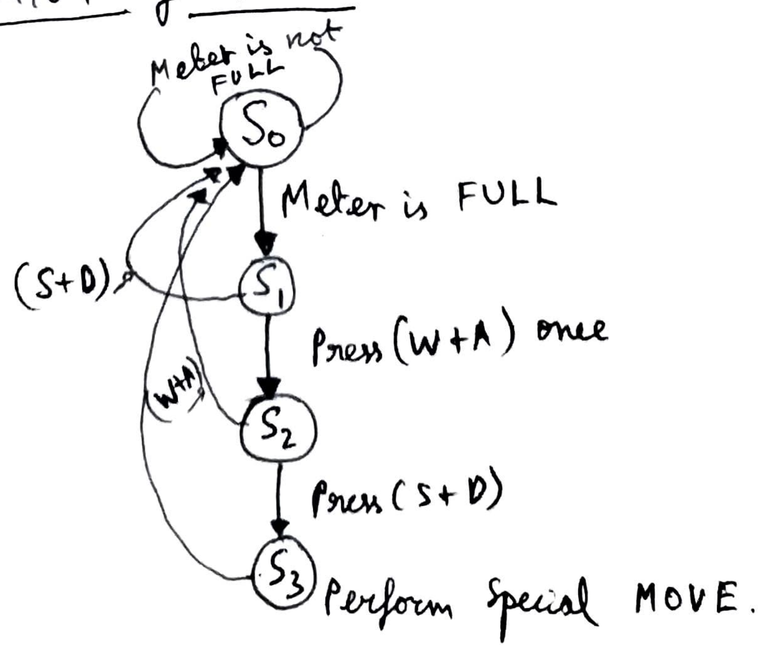
A2) Finite State machine for performing a Special Combo in a GAME.

⇒ Problem Statement :-

While playing the game we have a meter. When the meter is full the user can perform a special move by pressing the following sequence of keys in the keyboard.

1) Meter is full
2) Press (W+A) once, if (S+D) is pressed the combo is broken.
3) Press (S+D), if (W+A) is pressed again combo is broken.
4) Perform the special move and go back to the initial state.

Step 1 Representation of FSM.



Step ② :- Encoding the States

	Q_0	Q_1
S_0	0	0
S_1	0	1
S_2	1	0
S_3	1	1

} States

	I_0	I_1
Meter is FULL	0	0
Meter is NOT FULL	0	1
Press (W + A)	1	0
Press (S + D)	1	1

} Inputs

D-FLIP FLOP (Excitation Table)

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

Step ③ :- Truth Table

Q_0	Q_1	I_0	I_1	Q_0^+	Q_1^+	D_0	D_1	Output (Special Move)
0	0	0	0	0	1	0	1	0
0	0	0	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0
0	1	0	0	0	1	0	1	0
0	1	0	1	0	1	0	1	0
0	1	1	0	1	0	1	0	0
0	1	1	1	0	0	0	0	0
1	0	0	0	1	0	1	0	0
1	0	0	1	1	0	1	0	0
1	0	1	0	0	0	0	0	0
1	0	1	1	1	1	1	1	1 (Special MOVE is performed)
1	1	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0
1	1	1	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0

Step 4 : Simplification Using K-Maps.

i) For D_0

$Q_0Q_1 \backslash I_0I_1$	00	01	11	10
00	0	1	3	2
01	4	5	7	1 (6)
11	12	13	15	14
10	1 (8)	1 (9)	1 (11)	10

$$\Rightarrow \boxed{D_0 = \bar{Q}_0 Q_1 I_0 \bar{I}_1 + Q_0 \bar{Q}_1 \bar{I}_0 + Q_0 \bar{Q}_1 I_1}$$

ii) For D_1

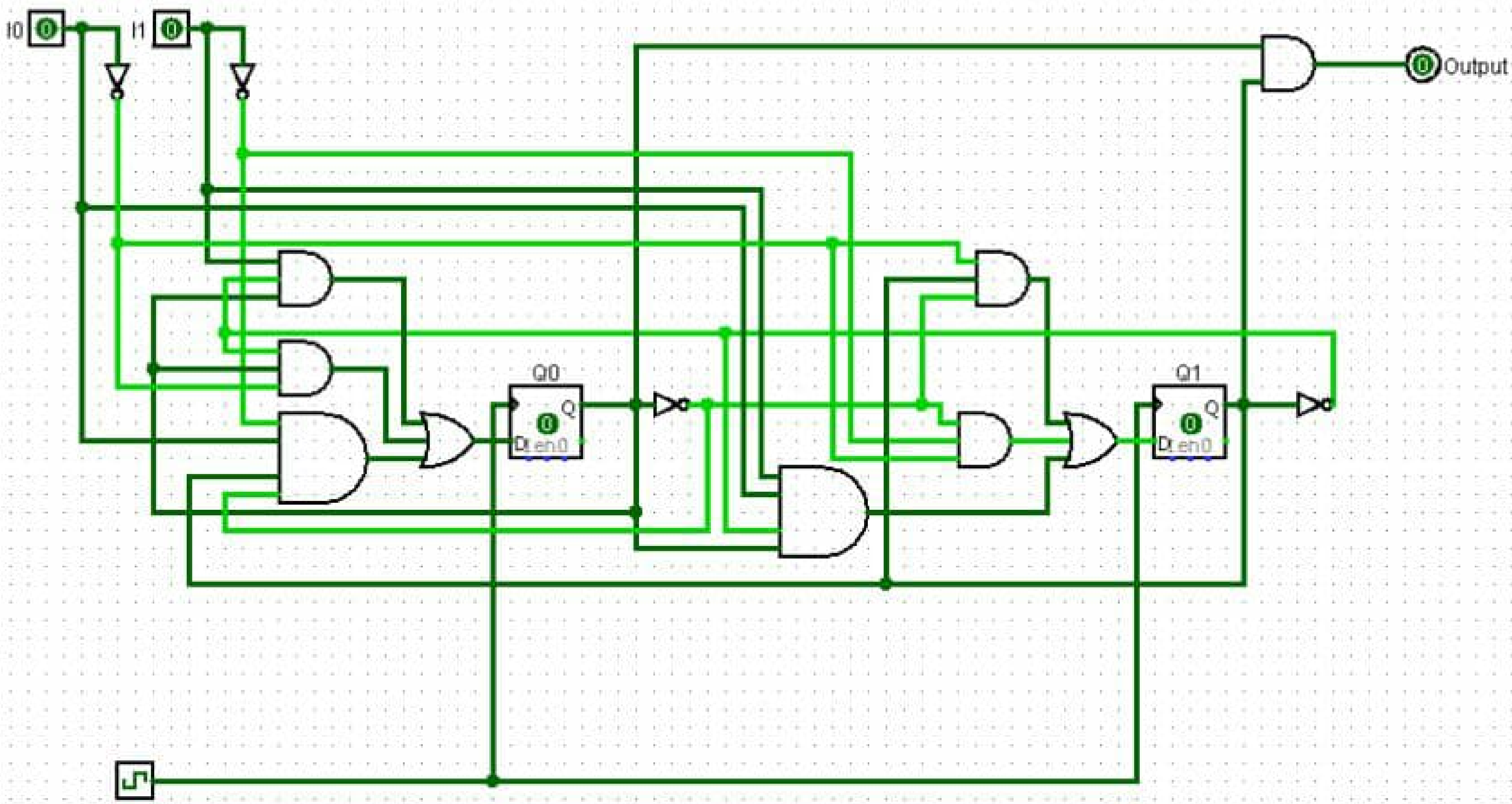
$Q_0Q_1 \backslash I_0I_1$	00	01	11	10
00	1 (0)	1	3	2
01	1 (4)	1 (5)	7	6
11	12	13	15	14
10	8	9	1 (11)	10

$$\Rightarrow \boxed{D_1 = Q_0 \bar{Q}_1 I_0 I_1 + \bar{Q}_0 \bar{I}_0 \bar{I}_1 + \bar{Q}_0 Q_1 \bar{I}_0}$$

Step 5 Create combinational logic

* Refer to the circuit in the image given below:

Finite State Machine Circuit Diagram

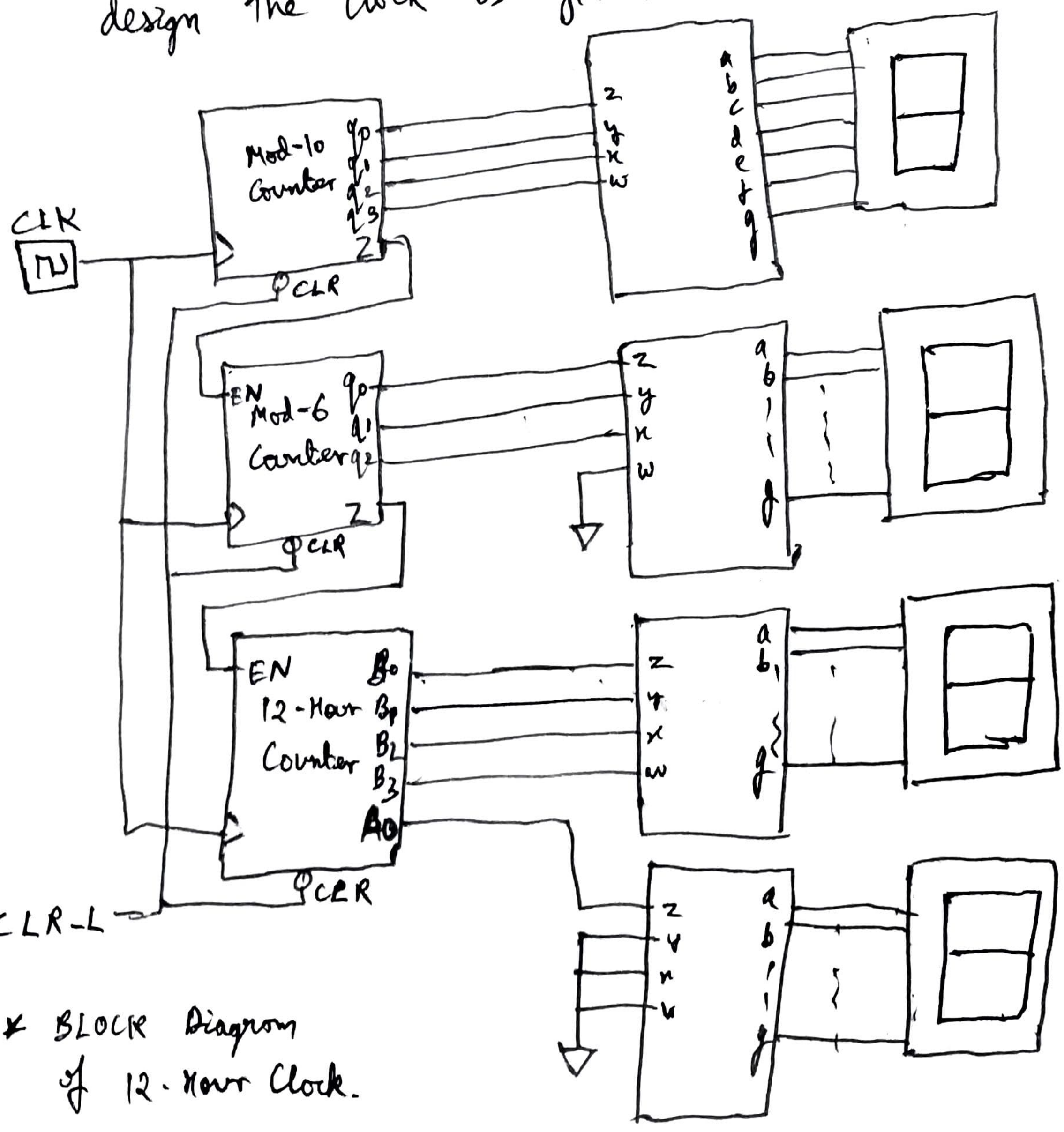


A3) Aim of the Experiment

→ To design a 12-HOUR CLOCK Using counters

Method

→ Digital Clocks are usually set up to start at 12:00, and they count 12:01, 12:02, 12:03 ---- 12:58, 12:59, 1:00, and so on. The one's place of the minutes (the right-most digit) counts 0, 1, 2, 3 --- 9 and then repeats, and a circuit that counts in that way is called a mod-10 counter. The ten's place of the minutes (second digit from the right) counts 0, 1, 2, 3, 4, 5, and then repeats, which is called a mod-6 counter. The hour counter counts 12, 1, 2, 3, 4, ---- 9, 10, 11, and repeats. One way to design the clock is given below:



* BLOCK Diagram of 12-Hour Clock.

* The output from each counter is a binary coded decimal (BCD) number that represents one of the digits in time, and BCD-to-Seven segment decoders are used to drive the seven segment displays.

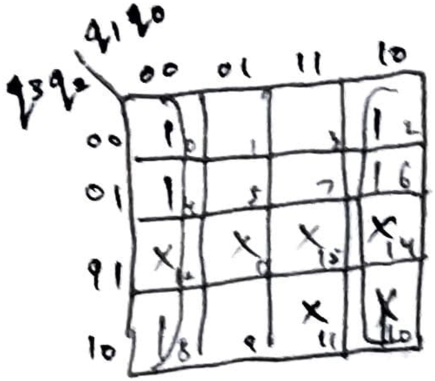
* The circuit is a clocked synchronous circuit where all the flip-flops have the same clock signal. If the clock signal is set to have one pulse per minute, the mod-10 counter will increament every minute and needs to have an output Z that indicates when it is at the maximum count (1001). Since the mod-6 counter only increments every 10 minutes, it needs to have an enable input which is connected to the max. count indicator Z that is 1 when the mod-6 counter is at the max. count (0101) and that it is enabled. The hour counter needs to have an enable input which is connected to the max. count indicator from the mod-6 counter.

* State Table for Mod-10 counter.

	q_3	q_2	q_1	q_0	q_3^+	q_2^+	q_1^+	q_0^+	Z
0	0	0	0	0	0	0	0	1	0
1	0	0	0	1	0	0	1	0	0
2	0	0	1	0	0	0	1	1	0
3	0	0	1	1	0	1	0	0	0
4	0	1	0	0	0	1	0	1	0
5	0	1	0	1	0	1	1	0	0
6	0	1	1	0	0	1	1	1	0
7	0	1	1	1	1	0	0	0	0
8	1	0	0	0	1	0	0	1	0
9	1	0	0	1	0	0	0	0	1
10	1	0	1	0	X	X	X	X	X
11	1	0	1	1	X	X	X	X	X
12	1	1	0	0	X	X	X	X	X
13	1	1	0	1	X	X	X	X	X
14	1	1	1	0	X	X	X	X	X
15	1	1	1	1	X	X	X	X	X

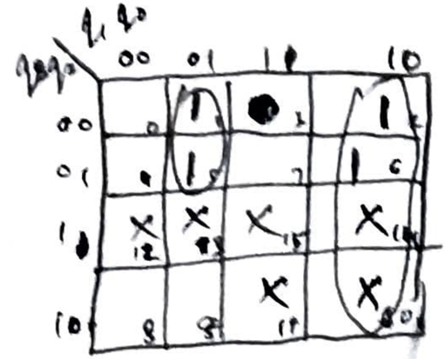
K-Map Simplification (Using D-Flip-Flops)

D_0



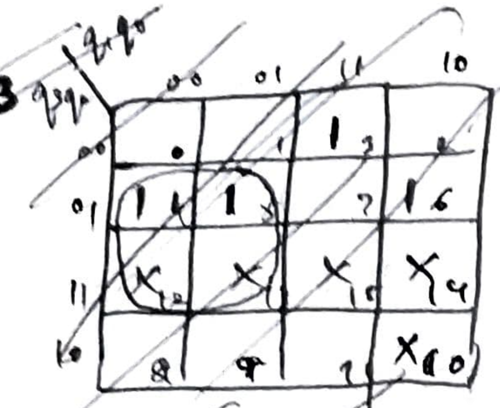
$$\boxed{D_0 = \bar{q}_0}$$

D_1



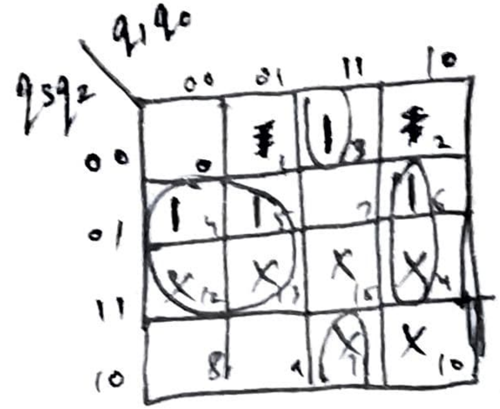
$$\boxed{D_1 = \bar{q}_3\bar{q}_1\bar{q}_0 + q_1\bar{q}_0}$$

~~D_3~~



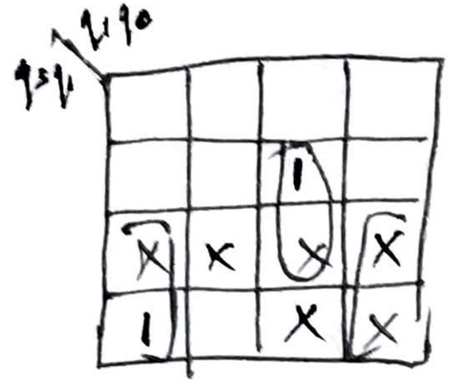
~~$D_3 = q_3q_0 + q_2q_1q_0$~~

D_2



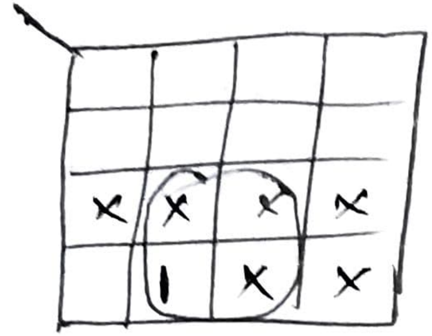
$$\boxed{D_2 = \bar{q}_2q_1q_0 + q_0\bar{q}_0 + q_2\bar{q}_1}$$

D_3



$$\boxed{D_3 = q_3q_0' + q_2q_1q_0}$$

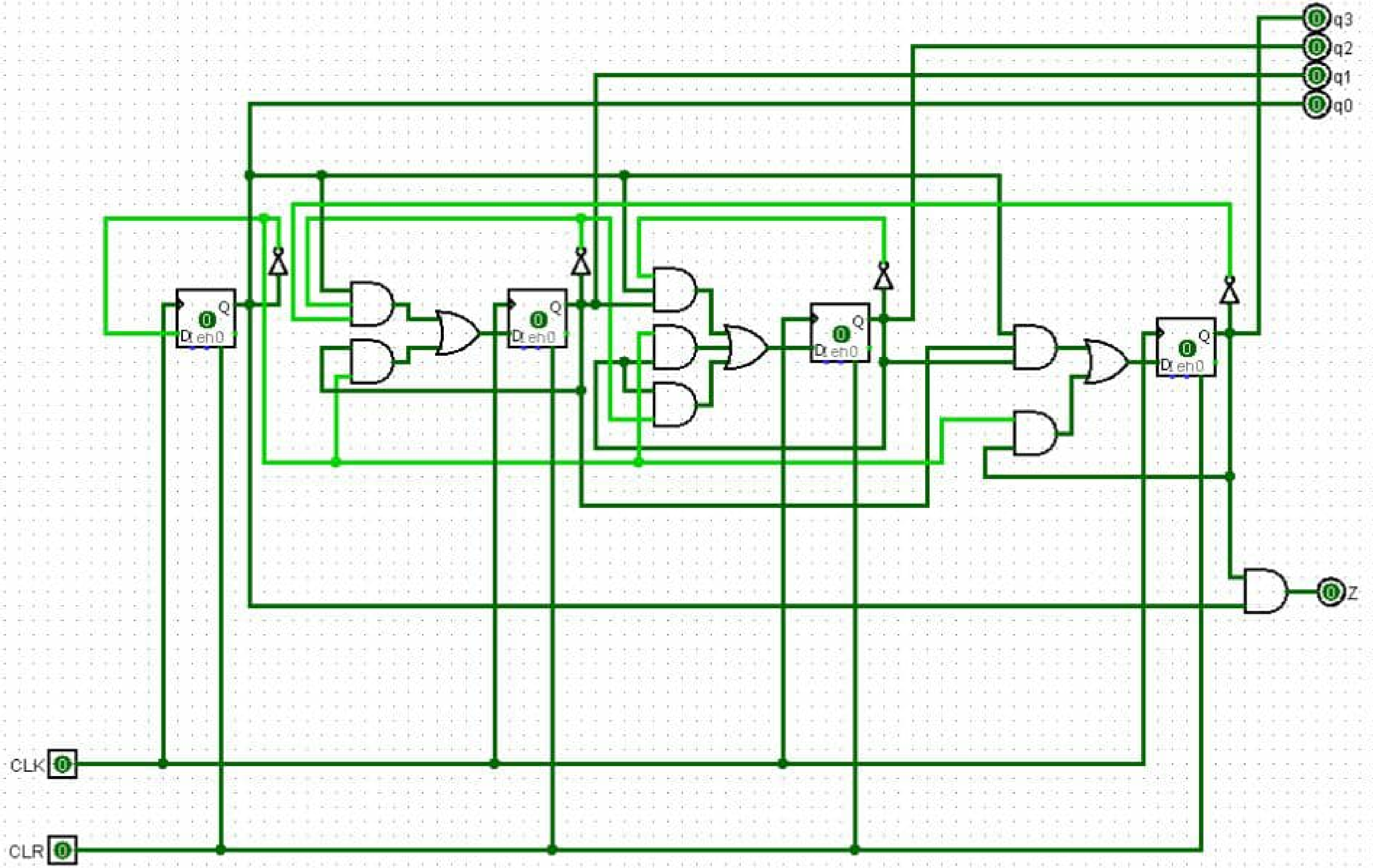
Z



$$\boxed{Z = q_3q_0}$$

Circuit :-

Mod-10 Counter



* State Table for mod-6 Counter.

q_2	q_1	q_0	$q_2^+ q_1^+ q_0^+$ E = 0	$q_2^+ q_1^+ q_0^+$ E = 1	Z E = 0	Z E = 1
0	0	0	0 0 0	0 0 1	0	0
0	0	1	0 0 1	0 1 0	0	0
0	1	0	0 1 0	0 1 1	0	0
0	1	1	0 1 1	1 0 0	0	0
1	0	0	1 0 0	1 0 1	0	0
1	0	1	1 0 1	0 0 0	0	1
1	1	0	X X X	X X X	X	X
1	1	1	X X X	X X X	X	X

D_0

$q_2 \backslash q_1 q_0$	00	01	11	10
0	1			1
1	1		X	X

$D_0 = \bar{q}_0$

If we use E, $D_0 = \bar{q}_0 E + q_0 \bar{E}$

$\boxed{D_0 = q_0 \oplus E}$

D_1

$q_2 \backslash q_1 q_0$	00	01	11	10
0		1		1
1			X	X

$D_1 = \bar{q}_2 \bar{q}_1 q_0 + q_1 \bar{q}_0$

If we use E,

$\boxed{D_1 = \bar{q}_2 \bar{q}_1 q_0 E + q_1 E + q_1 \bar{q}_0}$

D_2

$q_2 \backslash q_1 q_0$	00	01	11	10
0			1	
1	1		X	X

$D_2 = q_2 \bar{q}_0 + q_1 q_0$

If we use E, $\boxed{D_2 = q_2 \bar{E} + q_2 \bar{q}_0 + q_1 q_0 E}$

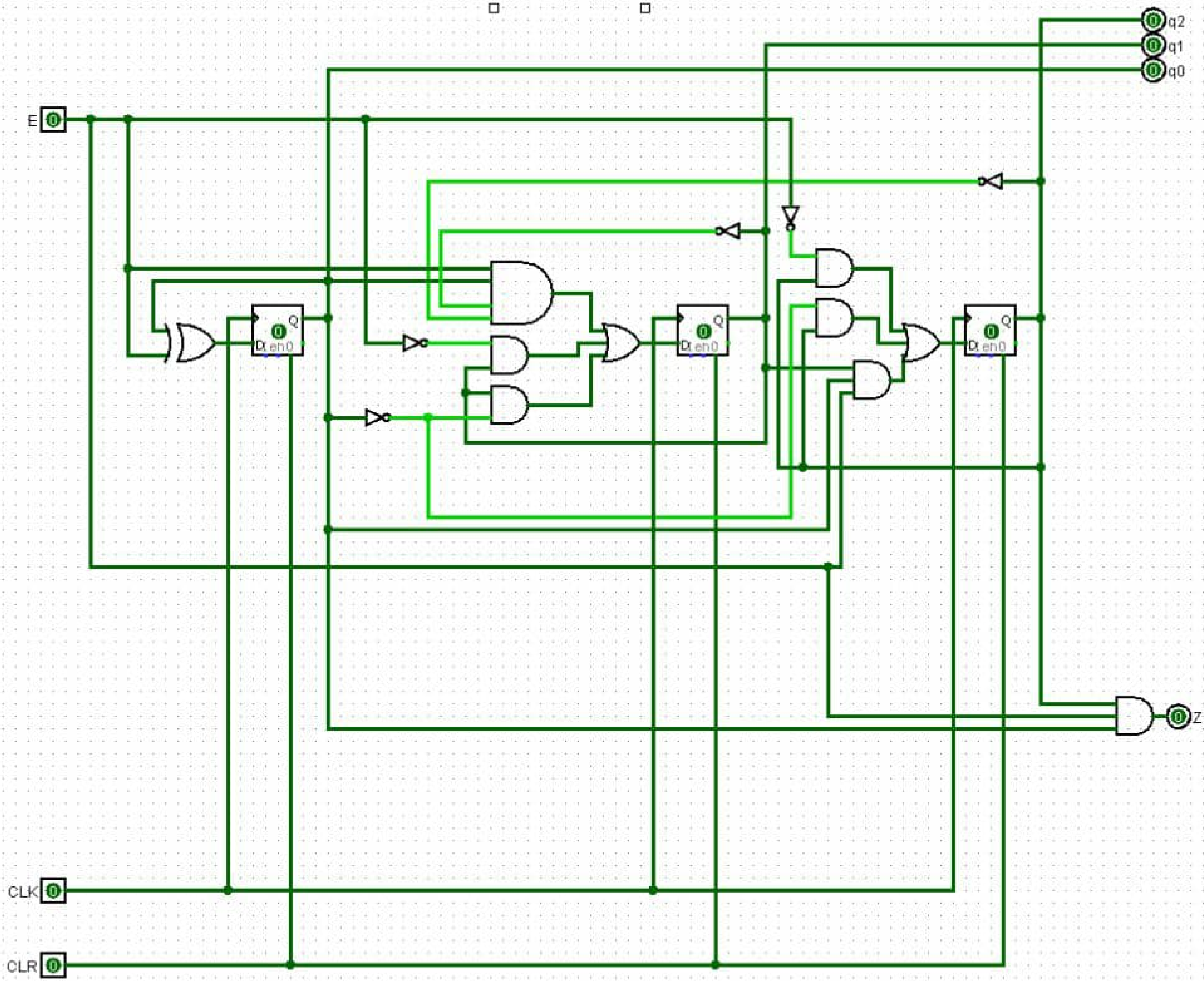
Z

$q_2 \backslash q_1 q_0$				
0				
1		1	X	X

$\boxed{Z = q_2 q_0 E}$

* Mod-6 Counter :- (Circuit)

Mod-6 Counter



* The hour counter has 12 states, and so it requires four flip-flops, Since the hour counter has four flip flops and one input, the excitation equations are functions of five variables. In order to avoid requiring five-variable K-Maps, the enable was implemented separately by using a flip-flops with <u>enable</u>.

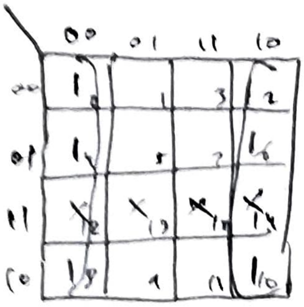
Therefore the hour counter was designed without an enable input so that excitation equations are functions of only four variables, but it was constructed using flip-flops with enable.

- <u>State Table for Hour Counter.</u>

q_3	q_2	q_1	q_0	q_3^+	q_2^+	q_1^+	q_0^+	A_0	B_3	B_2	B_1	B_0	Display
0	0	0	0	0	0	0	1	1	0	0	1	0	12
0	0	0	1	0	0	1	0	0	0	0	0	1	01
0	0	1	0	0	0	1	1	0	0	0	1	0	02
0	0	1	1	0	1	0	0	0	0	0	1	1	03
0	1	0	0	0	1	0	1	0	0	1	0	0	04
0	1	0	1	0	1	1	0	0	0	1	0	1	05
0	1	1	0	0	1	1	1	0	0	1	1	0	06
0	1	1	1	1	0	0	0	0	0	1	1	1	07
1	0	0	0	1	0	0	1	0	1	0	0	0	08
1	0	0	1	1	0	1	0	0	1	0	0	1	09
1	0	1	0	1	0	1	1	1	0	0	0	0	10
1	0	1	1	0	0	0	0	1	0	0	0	1	11
1	1	0	0	X	X	X	X	X	X	X	X	X	
1	1	0	1	X	X	X	X	X	X	X	X	X	
1	1	1	0	X	X	X	X	X	X	X	X	X	
1	1	1	1	X	X	X	X	X	X	X	X	X	

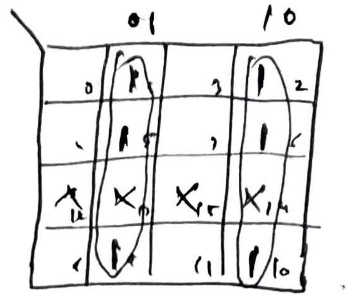
K-Map

D_0



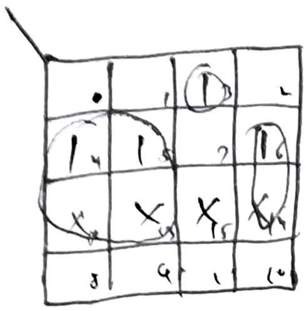
$\boxed{D_0 = q_0}$

D_1

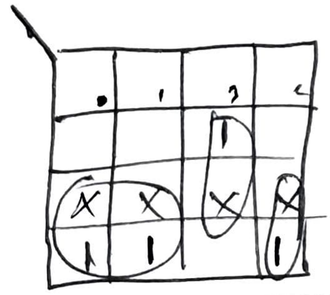


$\boxed{D_1 = q_1 \oplus q_0}$

D_2



D_3

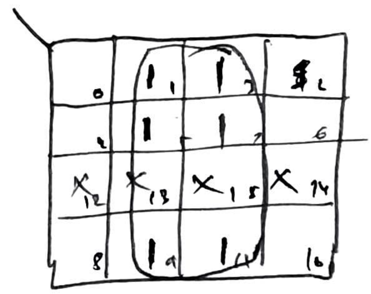


$\boxed{D_3 = q_2 q_1 q_0 + q_3 \bar{q}_1 + q_3 \bar{q}_0}$

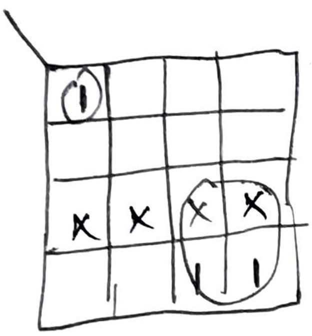
$\cancel{D_2 = q_2 q_1 q_0 + q_3 \bar{q}_1}$

$\boxed{D_2 = \bar{q}_3 \bar{q}_2 q_1 q_0 + q_2 \bar{q}_0 + q_2 \bar{q}_1}$

B_0



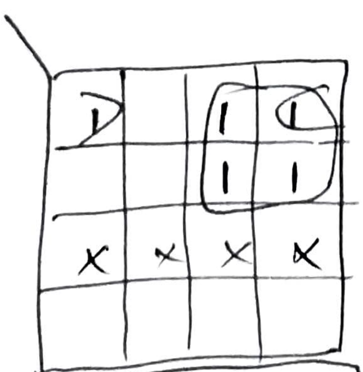
A_0



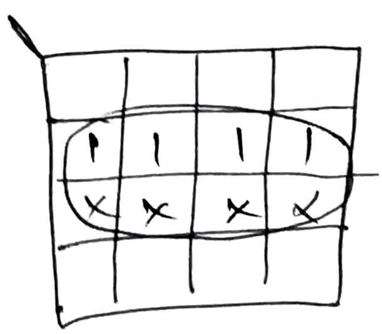
$\boxed{A_0 = \bar{q}_3 \bar{q}_2 \bar{q}_1 \bar{q}_0 + q_3 q_1}$

$\boxed{B_0 = q_0}$

B_1



B_2

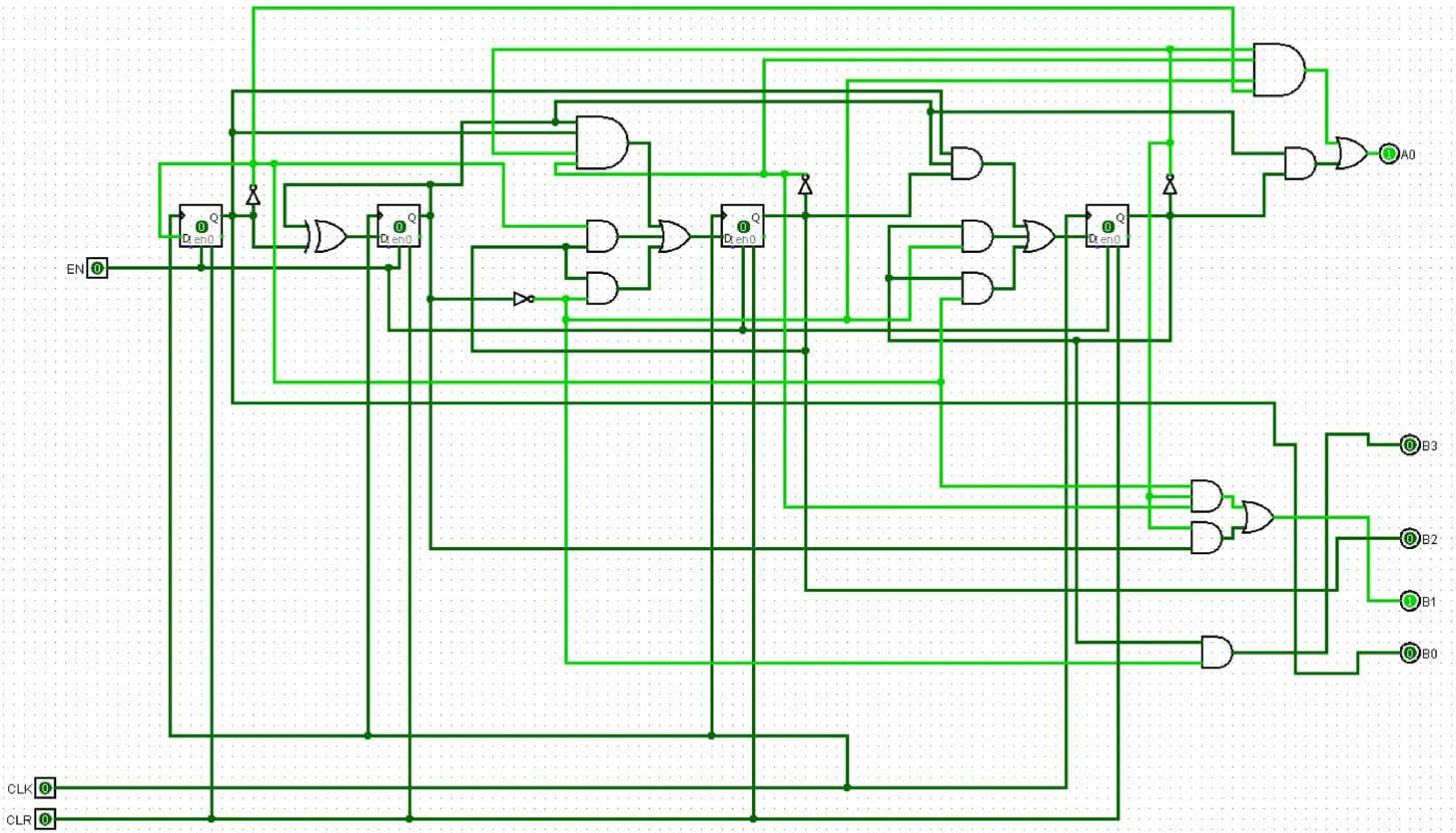


$\boxed{B_1 = \bar{q}_3 \bar{q}_2 \bar{q}_0 + \bar{q}_3 q_1}$

$\boxed{B_2 = q_2}$

$\boxed{B_3 = q_3 \bar{q}_1}$

12-Hour Counter



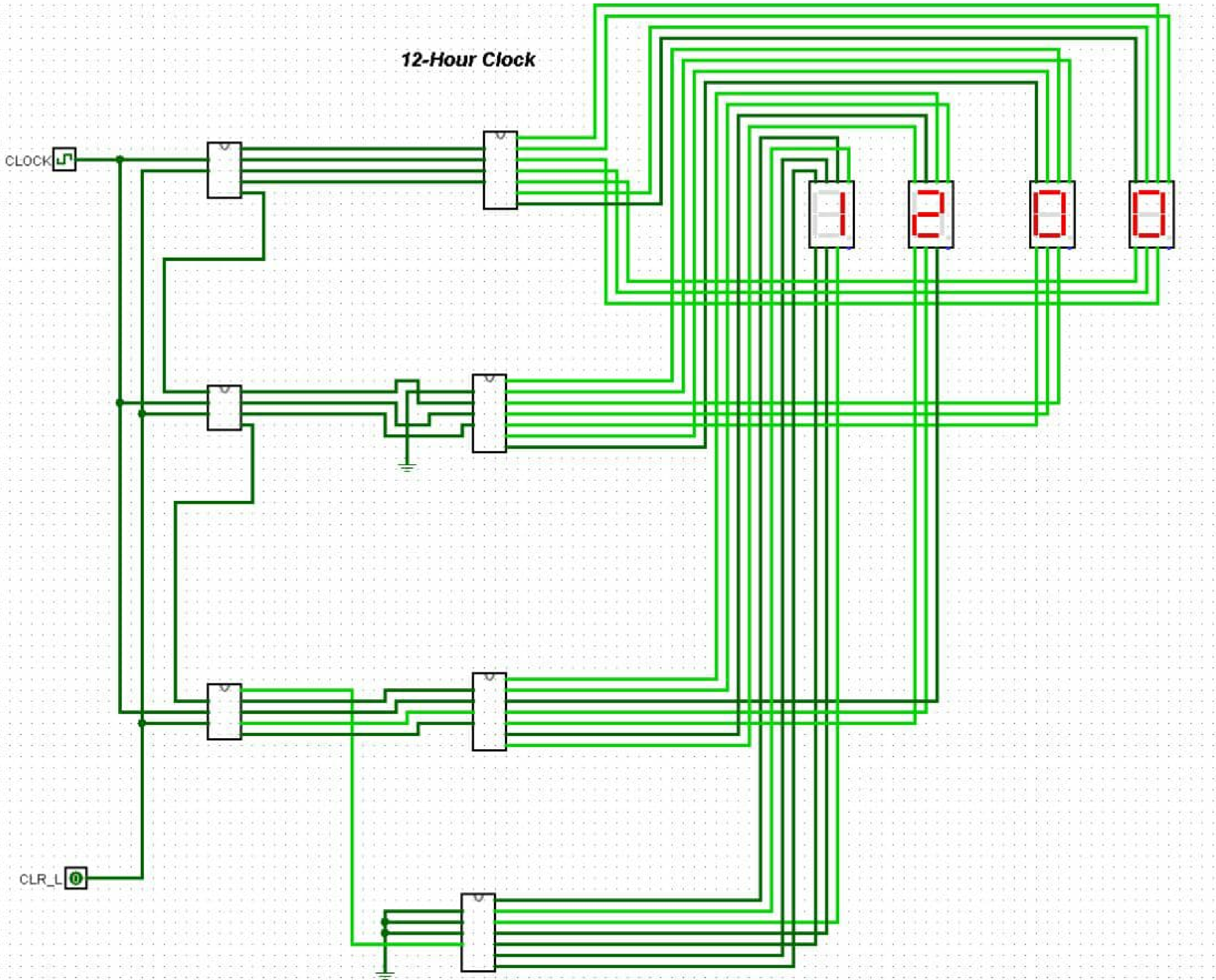
* The clock signal, which needs to have one pulse every minute, can be generated, by dividing the signal from a crystal oscillator down to the required frequency. The time can be set by having a button that allows the user to temporarily select a clock that has a higher frequency so that the clock counts quicker than normal.

Conclusion :-

→ We are able to implent a 12 - HOUR CLOCK using counters.

The circuit diagram is given below :-

12-Hour Clock



A1) Critical analysis report on Computer memory Architectures

Memory Types	***Year of Introduction***	***Application***	***Power Consumption***		***Memory Capacity***		***Speed***		***Technology Used***		***Number of tarnsisitors***	***Price***	
			Past	**Present**	**Past**	**Present**	**Past**	**Present**	**Past**	**Present**		Past	Present
DRAM	1959	DRAM is the main memory (called the "RAM") in modern computers and graphics cards (where the "main memory" is called the graphics memory).	less amount of power due to lesser nuber of transisitors and resistors	Nearly 3 Watts	128 Mbits	16GBs	Bus rate 66MHz	Bus rate 400Mhz	Bipolar Transistors were used	MOS Technology	Single DRAM is composed of only two components, a transitor and a capacitor. DRAM can be made in high densities		
SRAM	1965	Hard Disk Buffers, Cache Memory, etc	Very low power consuming device	82nW per bit.	In Bytes	1MB to 16MB	3200Mbps	19200Mbps	16-bit silicon memory chip based on the Farber-Schlig cell, with 80 transistors, 64 resistors, and 4 diodes	MOSFETs.	Each bit is stored on 4 transistors	$/Mbyte : 411,041,792	$/Mbyte : 0.0035
EEPROM	1972	Storing BIOS of the computer	Negligible		In order of Bytes	32 KB		Write access times in the area of 10ns	Antifuse bit cells dependent on a capacitor between crossing conductive lines	One thin Oxide Transistor per bit cell	2 transistors per bit	13$ for 2Kbit	2$ for 1024Kbit
PROM	1956	Video Game consoles,Old Cell Phones	Negligible		PROM comes with all bits reading as 1. Burning a Fuse bit during programming cause the bit to read as zero		The breakdown of a bit occurs in 100 micro seconds or less		PMOS	CMOS	1 Transistor per bit cell	$66 for 2Kbit	$24 for 16Kbit
CAM	2007	Netowrking Devices, databas engines,artificial neural networks etc	Negligible		Can store Binary or Ternary Bits		It is able to hit speeds of about 100Mhz in network devices		Cryptograhic Hash Function		4 n type Transistors	$/Mbyte : 411,041,792	$/Mbyte : 0.0035
EPROM	1971	In integrated Circuits and boards,Computer BIOS	Negligible		2 Kbit	32 Mbit	256Kbitps	8Mbitps	PMOS	CMOS	Two Transistors		
USB/FLash	1972	Storing small amount of data	Large amount of Power due to mechanical systems	A write takes about 60 mA at 3V for upto 3msec	256KBs	1TB	12 Mbit/s	5 Gbit/s	Floating Gate MOSFET transistors memory Cells	NAND FLash Memry Chips, Crystal Oscilator, USB Mass Storage Controller	16 GB flash drive consists of 64 Billion Transistors	US$/MB: 0.258	US$/MB: 0.000214
Registers	1944	buffer storage, I/O of different kinds	Negligible		Binary 1 or 0	Upto 64bit registers or even more		100GBps in processor Cache (L3)	Basic Gates using mechanical equipments	MOSFETs Semiconductors	Variable		
HDD	1956	Storing Large amount of data, One of the basic components of computers	High power consumption due to mechanical glass platters	10Watts	3.75 MB on a stack of 50 disks.	Upto 16TB on a single disk.	1Mbit/s	200 MBps	Reels of Magnetic tape	Modern HDD records data by magnetixing a thin film of ferrmagnetic material	Tens or Hundreds of Millions	US$/MB: 9200	US$/MB: 0.0000190
SSD	1991	As a fast storage device in various computing devices lik servers, gaming pcs,etc	20Watts	Nearly 4 Watts	20MB	100TB	0.65GBps	15GBps	DRAM volatile Memory	NAND FLash Non Volatile Memory	800 Billion transistors	$650 for 8KB	$30 for 240GB
Tape Drives	1991	Used for Offline and archival Data Storage	High amount of power consumption due to mechanical components	Only about 200 Watts for 140TB tape drive. Significantly less than the same sized HDD	224KB	20TB	In order of KBps	200MBps	First computer tape drive, used 1⁄2" nickel-plated phosphor bronze tape	Linear Tape File System (LTFS)			$6222 for 15TB